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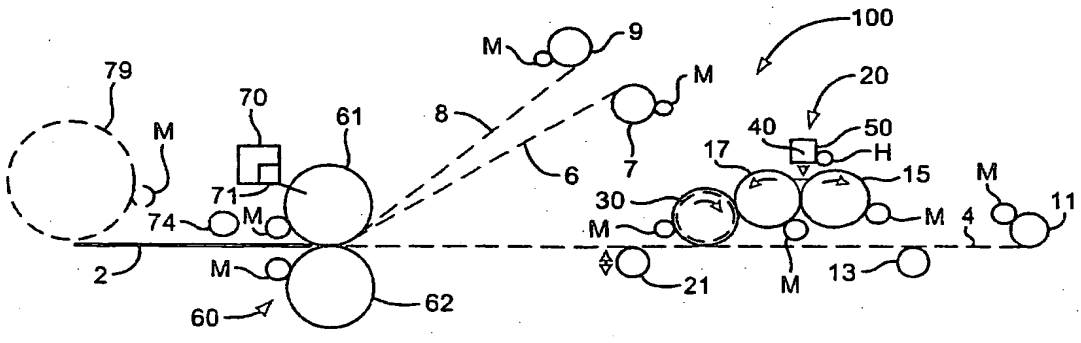
(54) Title: A METHOD OF MAKING A SCREEN, A SCREEN, AND A SYSTEM FOR MAKING A SCREEN



(57) Abstract: A method for making a screen assembly for a vibratory separator, the method comprising the steps of placing at least two layers of screening material one on top of the other, introducing glue to one of the at least two layers of screening material for adhering at least portions of them together, said glue introduced to one of the at least two layers of screening material from a roller with a patterned surface thereon such that the amount of glue is introduced to the at least two layers of screening material in a pattern substantially corresponding to said patterned surface of the roller. The invention also provides a method for making a screen, said method comprising the step of injecting glue on to a first screening material in a predetermined pattern, pressing at least a second screening material thereon to form a multi-layered screen. The invention also relates to a screen made by the methods and to systems for making a screen in accordance with the methods.

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A METHOD OF MAKING A SCREEN, A SCREEN, AND A SYSTEM FOR MAKING A SCREEN

This invention relates to a to a method of making a screen, a screen made by the method and A system for making a screen. The screens are more particularly, but not exclusively, for use in separating solids from circulating oil (mud) used in the drilling of oil and gas wells.

The need for solids control in drilling mud used in hydrocarbon well drilling is well known in the prior art. Drilling mud, typically a mixture of clay, water and various additives, is pumped down through a hollow drill string (pipe, drill collar, bit, etc.) into a well being drilled and exits through holes in the drill bit. The mud picks up cuttings (rock) and other solids from the well and carries them upwardly away from the bit and out of the well in a space between the well walls and the drill string. At the top of the well, the solids-laden mud is discharged over a shale shaker, a device which typically has a series of screens arranged in tiered or flat disposition with respect to each other. The screens catch and remove solids from the mud as the mud passes through them. The mud is then reused. If drilled solids are not removed from the mud used during the drilling operation, recirculation of the drilled solids can create weight, viscosity, and gel problems in the mud, as well as increasing wear on mud pumps and other mechanical equipment used for drilling.

In some shale shakers a fine screen cloth is used with the vibrating screen. The screen may have two or more overlying layers of screen cloth. The layers may be bonded together. A support, such as a perforated or apertured plate may be used beneath the screen or screens. The frame of the vibrating screen is resiliently suspended or mounted upon a support and is

caused to vibrate by a vibrating mechanism, for example, the vibrating mechanism may comprise an unbalanced weight on a rotating shaft connected to the frame. Each screen may be vibrated by vibratory equipment to create a flow of trapped solids on the top surfaces of the screen for removal and disposal of solids. The fineness or coarseness of the mesh of a screen may vary depending upon mud flow rate and the size of the solids to be removed.

Many screens used with shale shakers are flat or nearly flat (i.e. substantially two-dimensional). Other screens, due to corrugated, depressed, or raised surfaces are three-dimensional. U.S. Patents 5,417,793; 5,417,858; and 5,417,859 disclose non-flat screens for use with shale shakers. These screens have a lower planar apertured plate with a multiplicity of spaced-apart apertures or openings therethrough. The undersides of troughs of undulating screening material are bonded to the apertured plate. Such screens present a variety of problems, deficiencies, and disadvantages, including: decreased flow area due to area occluded by solid parts of the apertured plate; necessity to either purchase relatively expensive apertured plate or provide for in-house perforating of a solid plate; plate weight increases wear on parts such as rubber screen supports or cushions and can inhibit required vibration; large plate surface area requires relatively large amount of bonding means for bonding screens to the plate; and a finished screen which is relatively heavy increases handling problems, hazards, and cost of shipping.

A vibrating screen may be formed from one or more layers of wire mesh. Wire mesh is generally described with reference to the diameter of the wires from which it is woven, the number wires per unit length (called the mesh count) and the shape or size of the openings between

wires. Wire mesh comes in various grades. "Market" grade mesh generally has wires of relative large diameter. "Mill" grade has comparatively smaller diameter wires and "bolting cloth" has the smallest diameter wire. The type of mesh chosen depends on the application. Smaller diameter wires have less surface and thus less drag, resulting in greater flow rates. Smaller diameter wires also result, for a given opening size, in a larger percentage of open area over the total area of the screen, thus allowing greater flow rates and increased capacity. However, screens of bolting cloth tear more easily than market or mill grade screens, especially when used in harsh conditions such as drilling and mining operations. The smaller diameter wires tend to have less tensile strength and break more easily, and the finer mesh also tends not to retain its shape well.

Most meshes suffer from what is termed "near sized particle blinding". During vibration, wires separate enough to allow particles of substantially the same size or slightly larger than the openings to fall between the wires and become lodged, thus "blinding" the openings of the screen and reducing capacity of the screen. If a particle becomes lodged when the wires are at their maximum distance apart, it is almost impossible to dislodge the particle. Sometimes, however, wires will subsequently separate further to release the lodged particle. Unfortunately, some wire mesh, especially bolting cloth, is tensioned. Tensioning restricts movement of the wires. Restricting movement assists in holding the shape of the wire mesh, keeping the size of the openings consistent to create a more consistent or finer "cutting point" and reducing abrasion from wires rubbing against each other. However, restricted movement of the wires reduces the probability that, once a near sized particle becomes stuck, the wires will subsequently

separate to allow the particle to pass. Use of smaller diameter wires, with smaller profiles, helps to reduce blinding. With a smaller diameter wire, a particle is less likely to become lodged midway through the opening.

Multiple layers of mesh may be used to alleviate blinding. U.S. Patent No. 4,033,865, describes layering two meshes in a manner that results in at least one wire of the lower of the two meshes bisecting each opening in the upper mesh. The openings in each mesh are at least twice as wide as the diameters of the wires and the lower mesh has openings the same size as or slightly larger than the openings in the upper mesh. The lower mesh, when held tightly against the upper mesh, prevents particles from migrating far enough into an opening in the upper mesh to be trapped. Some relative movement of the layers also helps to dislodge particles caught in the upper layer. The two-layer arrangement has the further benefit of a finer "cutting point," allowing smaller particles to be separated out. A third "backing" layer of relatively coarse, mill grade mesh is often used to carry most of the load on the screen and to increase the tensile strength of the screen.

Another problem faced in most applications is the tearing of the screen. The problem can be especially acute in heavy duty applications such as drilling and mining. A torn screen must be replaced or repaired. To facilitate repair, the screen layers are bonded to a rigid or semi-rigid support panel that has a pattern of large openings, forming on the screen a plurality of small cells of wire mesh. When a tear occurs in the screen, the mesh remaining within the cell in which the tear occurred is cut out and the cell is plugged. The capacity of the screen is diminished but its life is extended. Typically, several cells of a screen can be repaired before its capacity drops far enough to require

replacement. Unfortunately, bonding the screen to the support panel further restricts relative movement of the layers and the wires in each mesh layer, thus compounding the problem of blinding.

Blinding and tearing of the screens reduce the capacity of the screen continually through its useful life. Although capacity can be increased by increasing the total area the screens, the size of the screen is limited in most applications, such as on drilling rigs, especially those on offshore platforms. There has thus been generally a trade-off between capacity, longevity, repairability and resistance to blinding of the screens. There is a need for a supported (either non-flat or flat) screen which is consumable, efficient and cost-effective, yet readily and inexpensively made, easy to handle, and relatively inexpensive to transport.

Accordingly, the present invention provides a method for making a screen assembly for a vibratory separator, the method comprising the steps of placing at least two layers of screening material one on top of the other, introducing glue to one of the at least two layers of screening material for adhering at least portions of them together, said glue introduced to one of the at least two layers of screening material from a roller with a patterned surface thereon such that the amount of glue is introduced to the at least two layers of screening material in a pattern substantially corresponding to said patterned surface of the roller.

Other features and steps in the method of the present invention are set out in claims 2 to 35.

The invention also relates to a screen made by the method and to a system for making a screen in accordance with the method.

The invention also provides a method for making a screen, said method comprising the step of injecting glue

on to a first screening material in a predetermined pattern, pressing at least a second screening material thereon to form a multi-layered screen.

Other features and steps in the method of the present invention are set out in claims 37 to 42.

The invention also relates to a screen made by the above method and to a system for making a screen in accordance with the method.

For a better understanding of the present invention, reference will now be made, by way of example, to the accompanying drawings, in which:

Figure 1 is a side schematic view of a first embodiment of an apparatus for making screens in accordance with the present invention, indicating steps in a method of making screens in accordance the present invention;

Figure 2 is a side schematic view of a second embodiment of an apparatus for making screens in accordance with the present invention, indicating steps in a method of making screens in accordance the present invention;

Figure 3 is an enlarged side view of an alternative roller apparatus for use in the apparatus as shown in Figures 1 or 2;

Figure 4A is an enlarged front view of part of a pattern roller for apparatus as in Figure 1;

Figure 4B shows a glue bead in cross-section;

Figure 5A is an end view of a first embodiment of a pattern roller;

Figure 5B is a side view of the roller of Figure 5A;

Figure 6A is an end view of a second embodiment of pattern roller ;

Figure 6B is a side view of the roller of Figure 6A;

Figures 7 and 8 are side views of alternative pattern rollers ;

Figure 9 is a top view of a screen in accordance with the present invention;

Figure 10 is a top view of a screen in accordance with the present invention with parts cut-away; and

Figure 11 is a side view of a pattern roller.

Figure 1 shows a system 100 according to the present invention for making a screen 2 according to the present invention by a method according to the present invention.

As shown the system 100 produces a screen 2 which includes a lower coarse mesh or screen 4, an intermediate mesh or screen 6, and a top mesh or screen 8. Any one of these meshes (or screens) 4, 6, 8 may be omitted. Alternatively one or more additional mesh layers may be added.

The coarse mesh 4 is initially wound on a roller 11 from which it is unwound and passes over a rotating roller 13. From the roller 13 the coarse mesh moves to a position beneath a gluing station 20 where glue in a pattern is applied on the coarse mesh 4. In one aspect the coarse mesh is 19 mesh made of wire with a diameter of about 0.32cm (0.126 inches). Of course any suitable mesh may be used.

A pattern roller 30 applies a layer of glue in a desired pattern onto the coarse mesh 4. Glue 40 from a reservoir/manifold 50 flows to a space forming a "pond" of glue between a first roller 15 and a transfer roller 17. Either or both of these rollers may be a heated roller. Alternatively, or in addition to heat from a heated roller or rollers, hot air from an optional heater H may be blown at the roller(s) and/or at the "pond", and/or it may heat the glue in the reservoir/manifold 50. The transfer roller 17 rotates counter-clockwise as viewed in Figure 1 and the first roller 15 rotates clockwise; thus a film of glue is deposited on the outer surface of the transfer roller 17 which film, in turn, contacts parts of a pattern in or on an outer surface of the pattern roller 30 which rotates clockwise as viewed in Figure 1. The film on the pattern parts of the pattern roller 30 is applied in the pattern onto the coarse mesh 4 moving beneath the pattern roller 30. In another aspect, glue is applied on top of a combination of two, three, or more meshes prior to entering between the rollers 61 (rather than on top of the coarse mesh

when it comes off the roll 11). In another aspect, the glue is applied only to the mesh from either the roll 9 or the roll 7.

An adjustable roller 21, whose tension against the mesh is adjustable by moving the roller up/down, supports the coarse mesh 4 with glue thereon. The coarse mesh 4 with glue thereon in a desired pattern determined by the pattern on the pattern roller 30 advances to a pressing station 60. The intermediate mesh 6 is fed between rollers 61 and 62 of the pressing station 60 from a roll 7 as is the top mesh 8 from a roll 9.

Between the rollers 61, 62, the three meshes are pressed together and the glue is pressed between all three meshes to bond them together. Optionally, coolant fluid from a coolant reservoir 70 is pumped with a pump 71 through one or both of the rollers 61, 62 to cool the mesh combination passing between the rollers 61, 62. The finished screen 2 (including all three meshes and glue) exit from between the rollers 61, 62. Optionally, a fan or fans and/or air movers or other cooling device(s) 74 may be used to cool the screen 2.

The various meshes for the screen 2 may be fed through the system 100 by hand and the finished screen 2 may be pulled by hand from between the rollers 61, 62 and/or one or more of the rollers in the system may be a driven roller, rotated by a motor appropriately connected to the roller for rotating it with desired speed and torque (for example, but not limited to, motors M driving rollers 61, 62). A suitable gearing system may be used interconnecting the motor and roller. In certain aspects one or more of the rolls and/or roller(s) are drive rolls and/or rollers which are rotated so that the mesh is moved through the system at a speed of between 6.1 and 18.3 metres per minute (twenty and sixty feet per minute). In other particular aspects, the speed is about

3.05 metres per second (ten feet per minute). Any or all of the rolls and/or rollers may be coated with polytetrafluorethylene and/or plastic ceramic, or cermet material. By adjusting roll and/or roller rotation speed, e.g. with suitable brake and/or drag apparatus, tension can be maintained on the mesh or meshes to keep it or them sufficiently taut while moving through the system. Motor Systems M represent (schematically) rotating systems for the rolls and/or rollers. Any, some, or all of the systems M may be omitted.

Optionally, the finished screen 2 may be wound onto a drum or roller 79.

Figure 2 shows a system 200 like the system 100 of Figure 1 with like parts indicated by like reference numerals in the one hundred series. The system 200 does not have the gluing station 20; but has a gluing apparatus 120 for applying a desired pattern of glue to the coarse mesh 104 that includes a glue reservoir/manifold 125 from which glue is supplied to a plurality of glue nozzles 126 (three shown). According to the present invention, a sufficient number of nozzles are used sufficiently spaced-apart and positioned to create a desired glue pattern on the coarse mesh 104. The resulting screen 102 is like the screen 2 and optional parts of the system 100 may be used in the system 200. Other features of the system of Figure 2 may be included in the system 200.

In other embodiments, a fine mesh is unwound from the roll 111 and fine, finer, or coarse mesh or meshes are unwound from the rolls 107 and 109.

Figure 3 shows one embodiment for a pressing station 67, like the pressing station 60, with rollers 68 and 69. A spring 66 biased between a support member 55 and a roller shaft mount 64 yieldingly urges the roller 68 against a multi-mesh combination 5.

The meshes 4, 6, and 8 or 104, 106 and 108 may be any mesh or screen disclosed herein. The glue 40, 140 may be any suitable glue, including, but not limited to, polyethylene glues and hot melt glues at a suitable temperature for flowing to and from a reservoir/manifold and onto a mesh, for example, but not limited to at about 121°C (250°F), between 121°C (250°F) and 204°C (400°F), or at other suitable temperatures for the particular glue being used.

Figures 5A and 5B show a pattern roller 80 useful as the pattern roller 30 of the system 100 in Figure 1. Raised portions 81 on an exterior surface 82 of the pattern roller 80 form the desired pattern for applying glue to a mesh. The roller 80 is solid with end shafts 83 for mounting to suitable supports for rotation. Any pattern roller disclosed herein may be solid with end shafts like the end shafts 83. Alternatively, recesses, holes, or indentations in one or both ends of the roller may be used to mount the roller to an appropriate shaft, mount, or support. Any of the pattern rollers disclosed herein, and any other roller used in systems according to the present invention, including, but not limited to systems as in Figures 1 to 3, may be coated with polytetrafluoroethylene.

Figures 6A and 6B show a roller 80a like the roller 80, but with a bore 84 through the roller from one end to the other. Such a bored roller or "sleeve" may be installed on a common shaft or roller positioned as is the pattern roller 30 in Figure 81. With a plurality of such sleeves with different patterns thereon, changing the system to produce a different glue pattern is greatly facilitated. Also, a worn or degraded sleeve is easily removed and replaced. Such sleeves also facilitate clean-up of the system.

It is within the scope of this invention for the

roller 80 (and any roller according to the present invention) to include only the raised portions 81 with no body or structure therebeneath nor between pattern components so that the portions 81 and ends of the roller not only define a pattern but also form a perforated tube or sleeve. Such a tube or sleeve may be made from a piece of solid stock by machining and/or laser cutting. Any pattern for a roller described herein may be formed by grooves or recesses in a roller surface rather than by raised portions on a roller surface.

Figures 7 and 8 present pattern rollers with patterns or raised portions different from that of the patterns of the rollers of Figures 5B and 6B. The rollers of Figures 7 and 8 may have any of the options of the rollers of Figures 5B and 6B (including, but not limited to end shafts 83 and bore 84, or a perforated tube structure). A roller 85 in Figure 7 has raised lines 86 that define a pattern across the roller. A roller 87 in Figure 8 has raised portions 88 and 89 that define a pattern across the roller.

Figure 9 shows a screen 90 produced with a system like the system 100 of Figure 1, using a roller like the roller 85 of Figure 7. Figure 10 shows a screen 92 with a glue layer 93 according to the present invention produced with a system like the system 100 of Figure 1 using a roller like the roller 87 of Figure 8. The screen 92 is like the screens disclosed in U.S. Patent 4,575,421 (incorporated fully herein for all purposes), but made with a system according to the present invention and by a method according to the present invention. The screen 92 has three layers of mesh or screening material 56, 57 and 58 and a lower perforated plate 54. Any of the layers of mesh may be omitted and the glue 93 may be applied on top of any of the layers. In one aspect the plate 54 is omitted. In one aspect the plate 54 is

deleted and any other support is used. The screen 90 is like a screen disclosed in U.S. Patents Des. 366,040 (incorporated fully herein for all purposes) and U.S. 5,971,159 (incorporated fully herein for all purposes). An optional frame 90a is used around the screen 90.

Figure 4A shows an enlargement of part of a pattern roller 96 which is similar to the roller 80 of Figure 5B, but which has valleys, recesses or grooves 97 in raised portions 98 of the roller. Glue is received within the grooves 97 so that a relatively higher or thicker level or bead of glue is applied to a mesh by the roller as compared to the layer or film of glue applied by a roller like the roller 80. Any raised portion of any roller disclosed herein may include such a valley recess, or groove to increase the amount of glue applied on a mesh. In one aspect the grooves 97 are between about 0.8mm (one-thirtysecond inch) to about 1.6mm (one-sixteenth inch) deep and in one particular aspect are about 1.6mm (one-sixteenth of an inch) deep. Viewed on end in cross-section the grooves may be V or U shaped, square-shaped, trapezoidal, or semicircular. Optionally the roller 96 has a bore through it (like the bore 84 of Figure 6B) and holes are provided through the roller so that the roller's interior is in fluid communication with the grooves via the holes and glue can be flowed or pumped from the roller interior to the grooves to provide the glue for the pattern to be applied to the mesh. Alternatively, in embodiments in which the grooves are not used, holes are provided through the roller through the raised portions of a patterned surface. Figure 4B shows a cross-section of one glue bead's B profile applied to a screen S with a pattern roller having grooves in raised portions of the pattern. The distance "a" is, in this embodiment, about 0.16cm (one-sixteenth of an inch). Preferably the distance "b" is as thin as

possible. It is within the scope of this invention to provide partial grooves or recesses in only a portion of the raised portions of a pattern rollers surface, e.g., but not limited to, only to the outer edges or only to the center, only to the edges and center, or only to certain spaced-apart portions on the roller to create a series of strips on the screen.

Fig. 11 shows a pattern roller 100 which has raised pattern areas 101 for forming a series of strips of glue on a screen or mesh or combination of layers thereof, including, but not limited to, a series of strips like the strips shown above. It is within the scope of this invention to use an appropriately configured pattern roller to form any series of strips (like any series of strips disclosed herein for a screen or panel) on a screen or mesh with glue as described above. It is also within the scope of this invention for the areas or parts of them to have grooves around their entire surface (grooves or recesses as described above) or in part of the surfaces. Such a roller with or without grooves may also have holes as described above for introducing glue from the interior of the roller to the grooves and/or to the raised areas. By using a roller like the roller 100 with only the two outer raised portions 101, two spaced-apart sides can be created on screen or mesh. By turning a piece of such screen or mesh ninety degrees and feeding it again through a gluing system two additional spaced-apart sides are created so that all four sides of the screen or mesh are glued.

CLAIMS:

1. A method for making a screen for a vibratory separator, the method comprising the steps of placing at least two layers of screening material one on top of the other, introducing glue to one of the at least two layers of screening material for adhering at least portions of them together, said glue introduced to one of the at least two layers of screening material from a roller with a patterned surface thereon such that the amount of glue is introduced to the at least two layers of screening material in a pattern substantially corresponding to said patterned surface of the roller.

2. A method according to Claim 1, comprising the step of introducing a third layer of screening material onto said at least two layers.

3. A method according to Claim 1 or 2, wherein the at least two layers of screening material includes at least a first layer and a second layer, the first layer comprising coarse mesh and the second layer comprising fine mesh.

4. A method according to Claim 1, 2 or 3 wherein the at least two layers of screening material comprises at least a first layer and a second layer, the first layer wound onto a first roll and the second layer wound onto a second roll, and the method further comprising unrolling the first layer from the first roll and unrolling the second layer from the second roll to place the layers adjacent each other.

5. A method according to Claim 4, wherein prior to placing the at least two layers of screening material one on top of the other, said glue is applied on the first layer.

6. A method according to Claim 4 or 5, wherein the glue is applied after the at least two layers of screening material are one on top of the other, onto the topmost

layer of the at least two layers.

7. A method according to any preceding claim, wherein the patterned surface comprises raised portions on the roller.

8. A method according to Claim 7, wherein said raised portions have a recessed portion therein for holding glue to be applied to the screening material in a pattern with a raised bead portion.

9. A method according to Claim 8, wherein said recessed portion is a groove.

10. A method according to any preceding claim, wherein the roller with the patterned surface is a first roller and a second roller is rotatably mounted adjacent the first roller to receive glue from a glue reservoir and apply the glue to the first roller.

11. A method according to Claim 10, wherein a third roller is rotatably mounted adjacent the second roller such that a pond of glue is maintained between the second roller and the third roller and glue from the pond of glue is transferred by the second roller to the first roller.

12. A method according to Claim 1 wherein glue is flowed directly onto the first roller from a reservoir of glue.

13. A method according to any preceding claim, wherein glue is flowed to an interior of the first roller from a reservoir of glue and wherein the interior of the roller is in fluid communication with said patterned surface via a series of holes such that glue is movable from the roller's interior, to the grooves, to the patterned surface on the roller.

14. A method according to any preceding claim, further comprising pressing together the at least two layers of screening material and the amount of glue.

15. A method according to Claim 14, wherein the at least two layers are pressed together between two opposed

dependent thereon, wherein the second roller is a driven roller.

26. A method according to Claim 11 or any claim dependent thereon, wherein the third roller is a driven roller.

27. A method according to any preceding claim, further comprising the step of heating the glue.

28. A method according to Claim 11 or any claim dependent thereon, further comprising the step of heating the pond of glue.

29. A method according to Claim 12 or any claim dependent thereon, further comprising the step of heating glue in the reservoir of glue

30. A method according to Claim 4 or any claim dependent thereon, wherein the first roll and the second roll are heated rolls.

31. A method according to any preceding claim, wherein the roller with a patterned surface is a heated roller.

32. A method according to Claim 10 or any claim dependent thereon, wherein the second roller is a heated roller.

33. A method according to Claim 11 or any claim dependent thereon, wherein the third roller is a heated roller.

34. A method according to any preceding claim, wherein the pattern extends over substantially the entire surface of the layers of screening material.

35. A method according to Claim 9 or any claim dependent thereon, wherein the raised portions with grooves are positioned on the pattern roller so that raised bead portions extend along spaced apart outer edges of the screen assembly.

35. A screen made by a method according to any preceding claim.

36. A system for manufacturing a screen comprising

components for carrying out the method as claimed in any of Claims 1 to 35.

37. A method for making a screen, said method comprising the step of injecting glue onto a first screening material in a predetermined pattern, and pressing at least a second screening material thereon to form a multi-layered screen.

38. A method as claimed in Claim 37, wherein the step of injecting glue is carried out by a plurality of injectors.

39. A method as claimed in Claim 37 or 38, wherein the step of pressing is carried out by rollers.

40. A method as claimed in Claim 37, 38 or 39, comprising the step of pressing at least a third screening material onto the second to form a multi-layered screen.

41. A screen made by a method according to any of Claims 37 to 40.

42. A system for manufacturing a screen comprising components for carrying out a method as claimed in any of Claims 37 to 40.

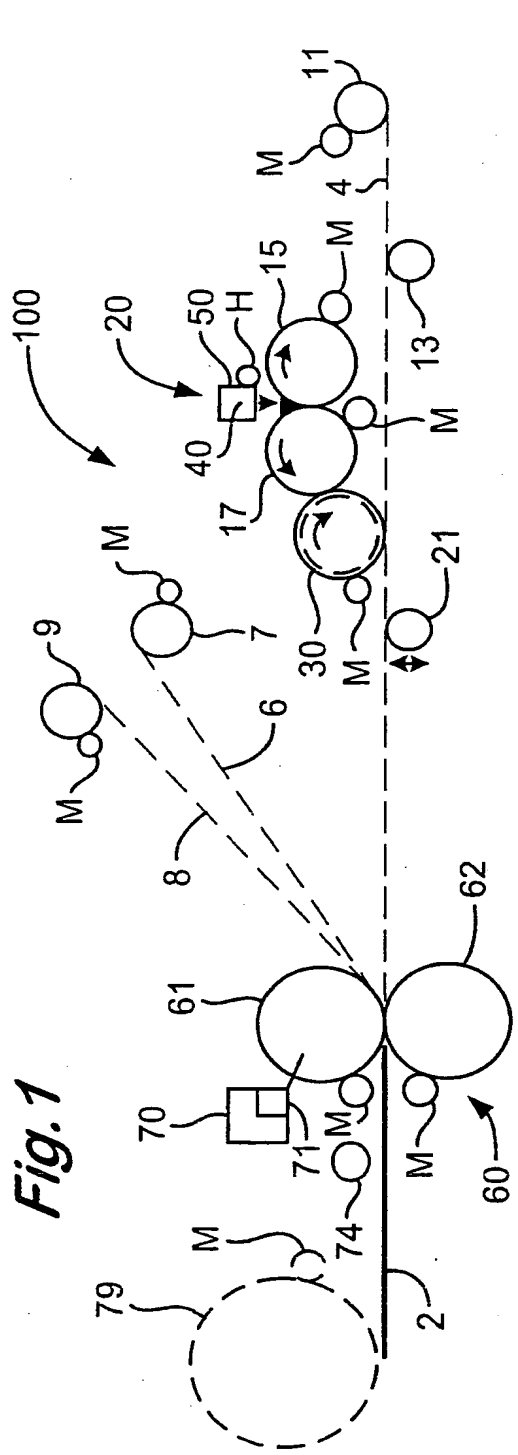
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Fig. 1

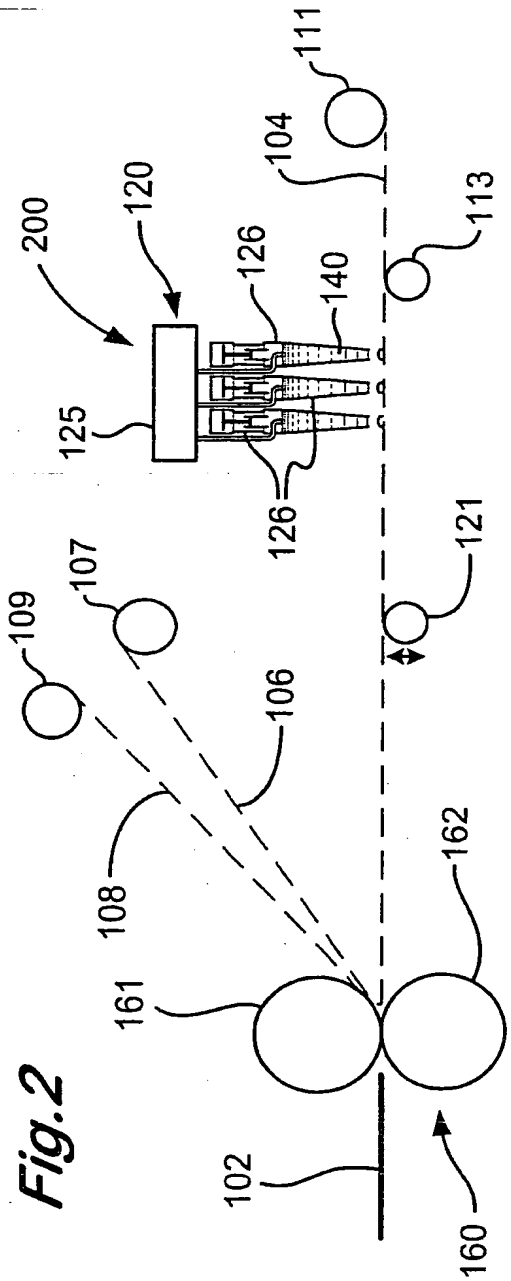
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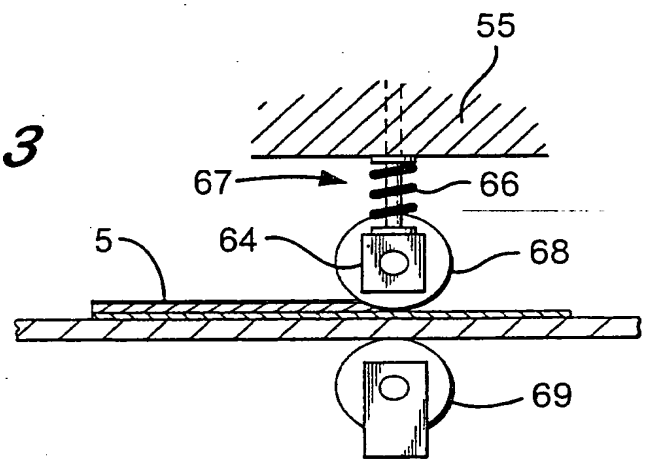
Fig. 2

Fig.3



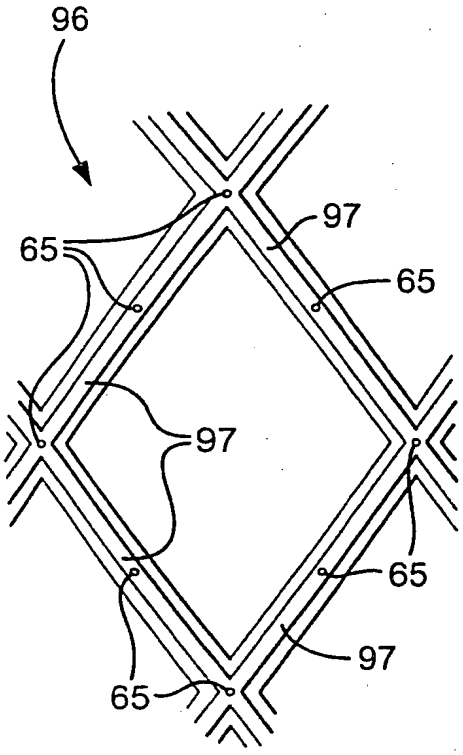
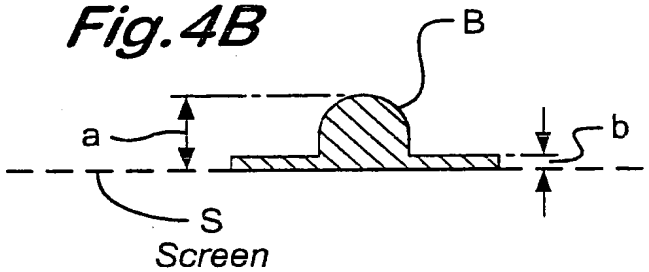


Fig.4A

Fig.4B



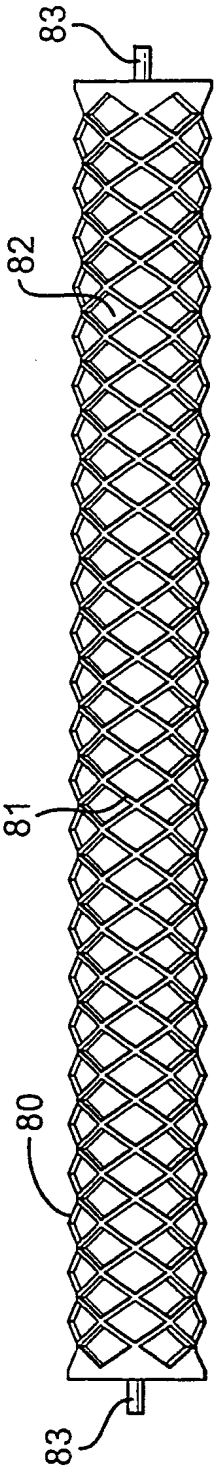


Fig.5B

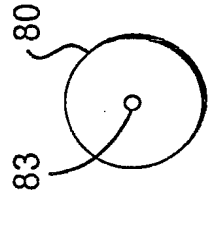


Fig.5A

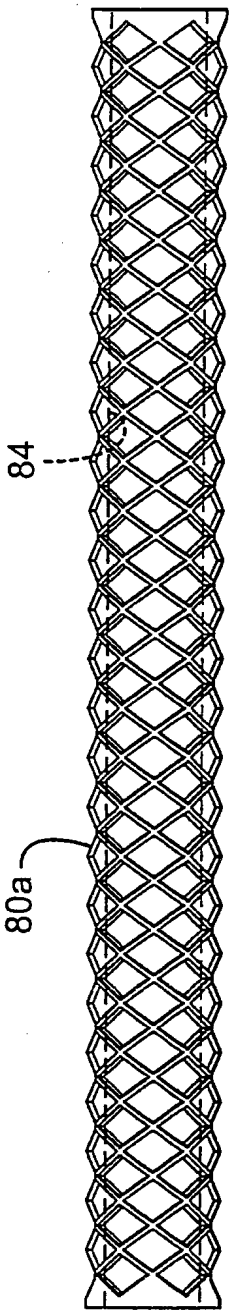


Fig.6B

Fig.6A

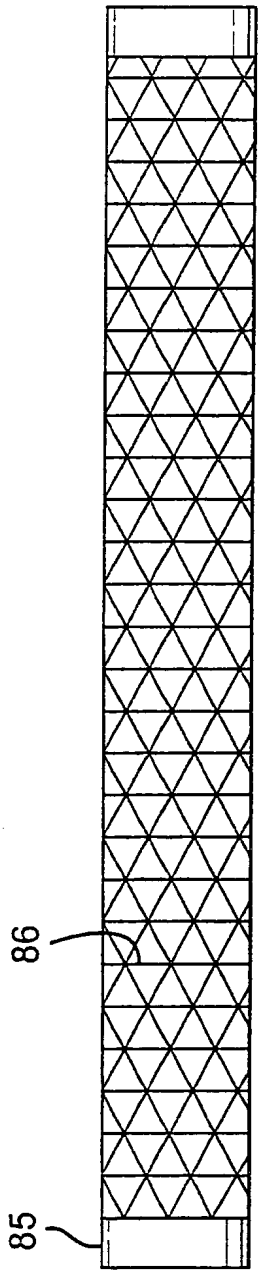


Fig.7

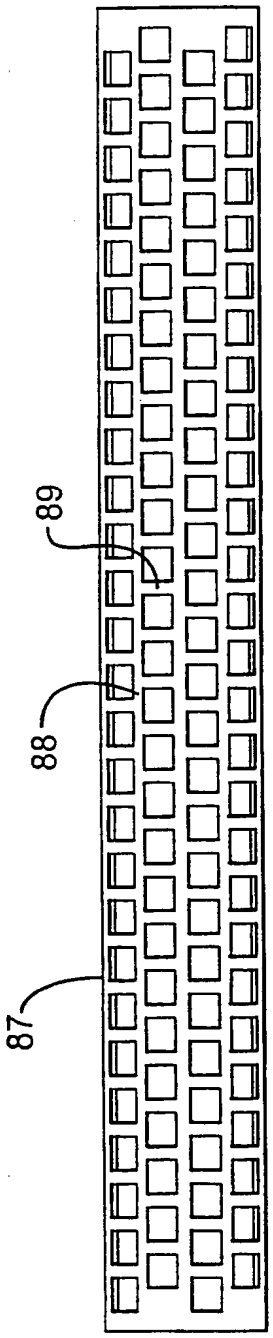


Fig.8

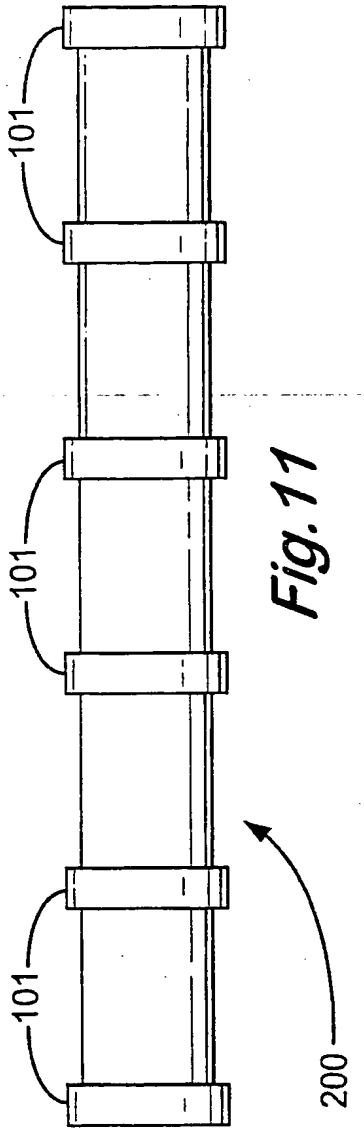


Fig.11

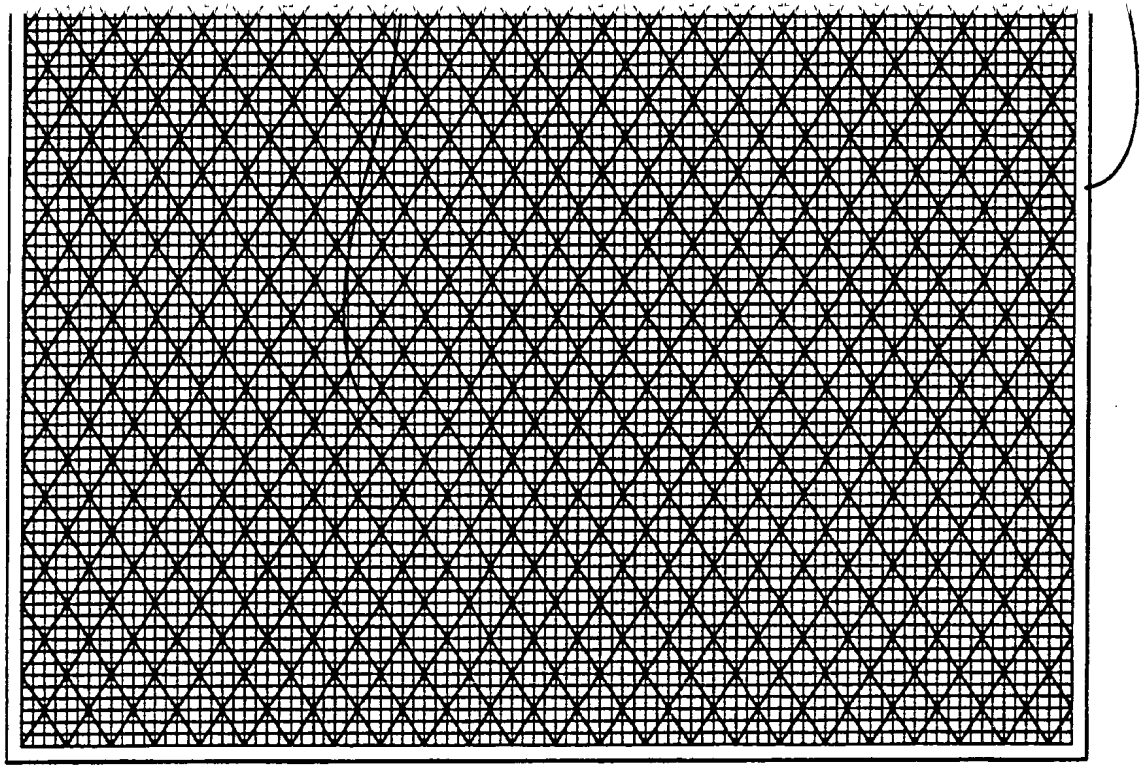


FIG.9

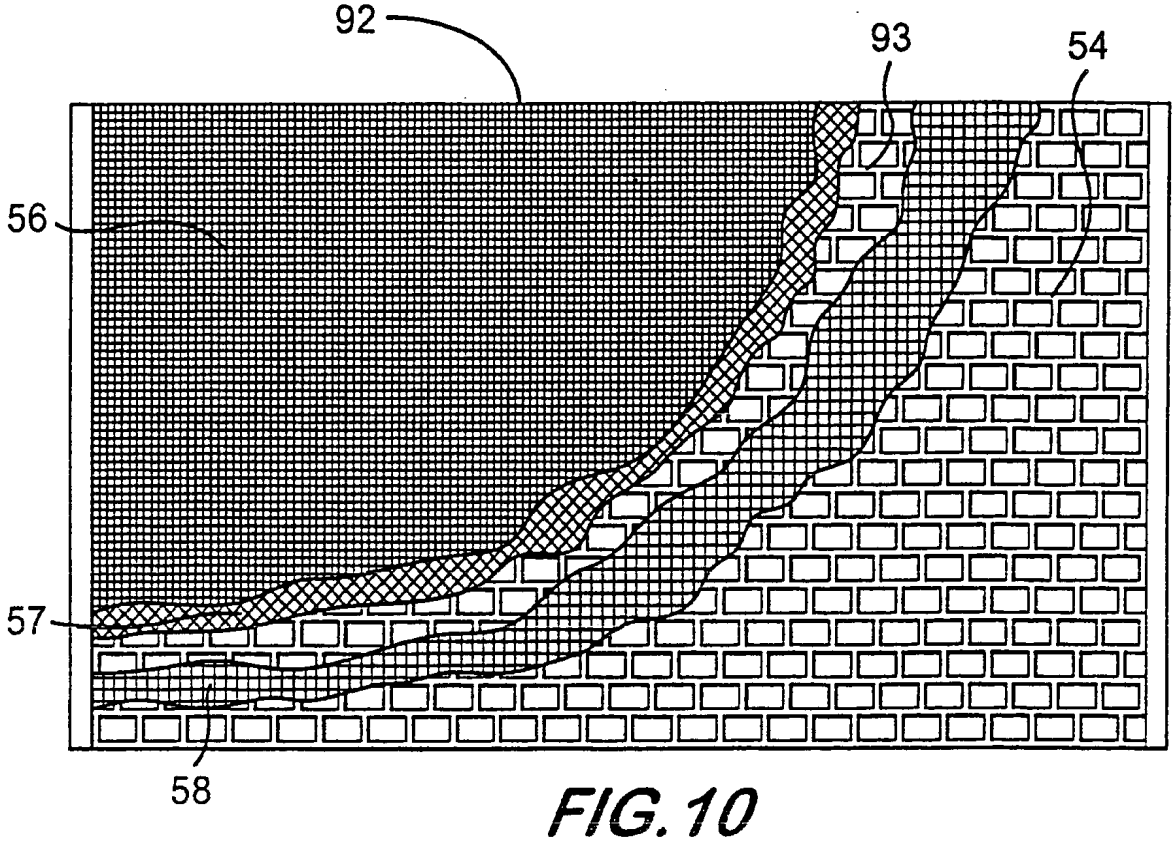


FIG.10

INTERNATIONAL SEARCH REPORT

Int. I Application No
PCT/GB 00/04615

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B01D33/03 B07B1/46

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B01D B07B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2 312 858 A (CRAVELLO WILLIAM MYRON) 12 November 1997 (1997-11-12) page 14, line 3 -page 15, line 9; claims 14,20; figures 3,3A	37,41,42
A	WO 95 17942 A (KAEHLER KAI ;DETROIT HOLDING LTD (IE)) 6 July 1995 (1995-07-06) page 9, line 18 -page 10, line 20; claims 1,10; figures 1A,2	1,4,5, 12,37, 38,41,42
A	US 4 575 421 A (DERRICK JAMES W ET AL) 11 March 1986 (1986-03-11) cited in the application the whole document	1,37

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
28 February 2001	07/03/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Hild, U

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INTERNATIONAL SEARCH REPORT

Int	I Application No
	PCT/GB 00/04615

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 858 091 A (DUWENDAG RUEDIGER ET AL) 12 January 1999 (1999-01-12) column 3, line 4 - line 16; claim 1; figures 1,2	1

1

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		JP 9131556 A	20-05-1997

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